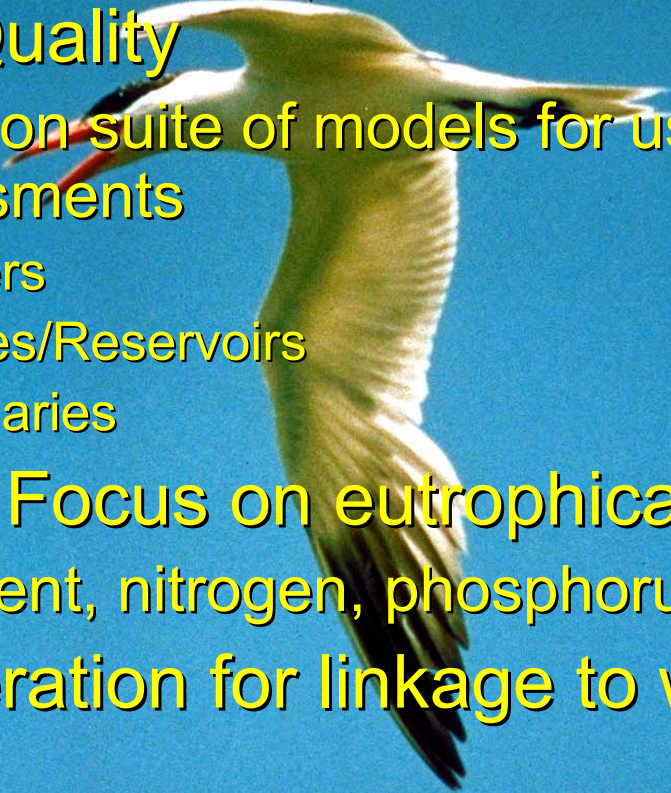# Selection of Water Quality Models for use in Total Maximum Daily Load (TMDL) Analyses

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TMDL Model Needs

- **Water Quality**
  - Common suite of models for use in TMDL assessments
    - Rivers
    - Lakes/Reservoirs
    - Estuaries
- **Primary Focus on eutrophication**
  - Sediment, nitrogen, phosphorus
- **Consideration for linkage to watershed models**
- **Ecological endpoint(s)**

Step 1

- Model Evaluation/Selection
  - Identify candidate models
    - Published literature
    - Internet
    - EPA reports/documents
  - Establish minimum requirements
    - Screen models based on criteria
      - Select initial candidate models

Sources

- Modeling Watershed Water quality (Donigian et. al., 1995
- EPA IMES (Versar, 1996)
- Evaluating Computer Models (WEST, 1996)
- EPA's Compendium Tools (Shoemaker, et al., 1997)
- Hydrodynamics and Water Quality Modeling (Martin and McCutcheon, 1998)
- Technical Evaluation of Existing Models (Tetra Tech, 1997)
- USGS SMIG web page, 1999

Minimum Requirements

- Well developed representation sediment, nutrients, and some plankton species
- Internally or successfully coupled to a hydrodynamic model
- Documentation of algorithms, operational instructions and flow of execution
- Have had at least 3 applications during the last 10 years with one other than the developer
- Code should be non-proprietary or must be a one-time purchase without a run-time license
- PC-compatible platform is required
- For reservoir and estuary models, multi-dimensional capability

Step 2

- Perform detailed evaluation candidate models
  - Model theory
  - Translation of theory into mathematical representation
  - Testing/publication
  - Model code and architecture
  - Availability
  - Technical support/expertise
  - Linkage to watershed models

Model Theory

- Three elements
  - hydrodynamics
  - Sediment
  - Nutrient cycling
- Two-tiered approach
  - Head-to-head
    - Dimensionality, transport, and capabilities
  - Internal
    - State variables and processes

Model Support

- Availability of developer or sponsor
- User groups
- Workshops
- Web sites
- Recurring conference/symposia

Model Usage

- **Application history**
- **Resource requirements for application**
  - Level of effort
  - Data required
  - Expertise required

Model Code

- Architecture
  - Static analyzer (Moniot, 1998)
    - Flow or execution
    - Adherence to coding conventions
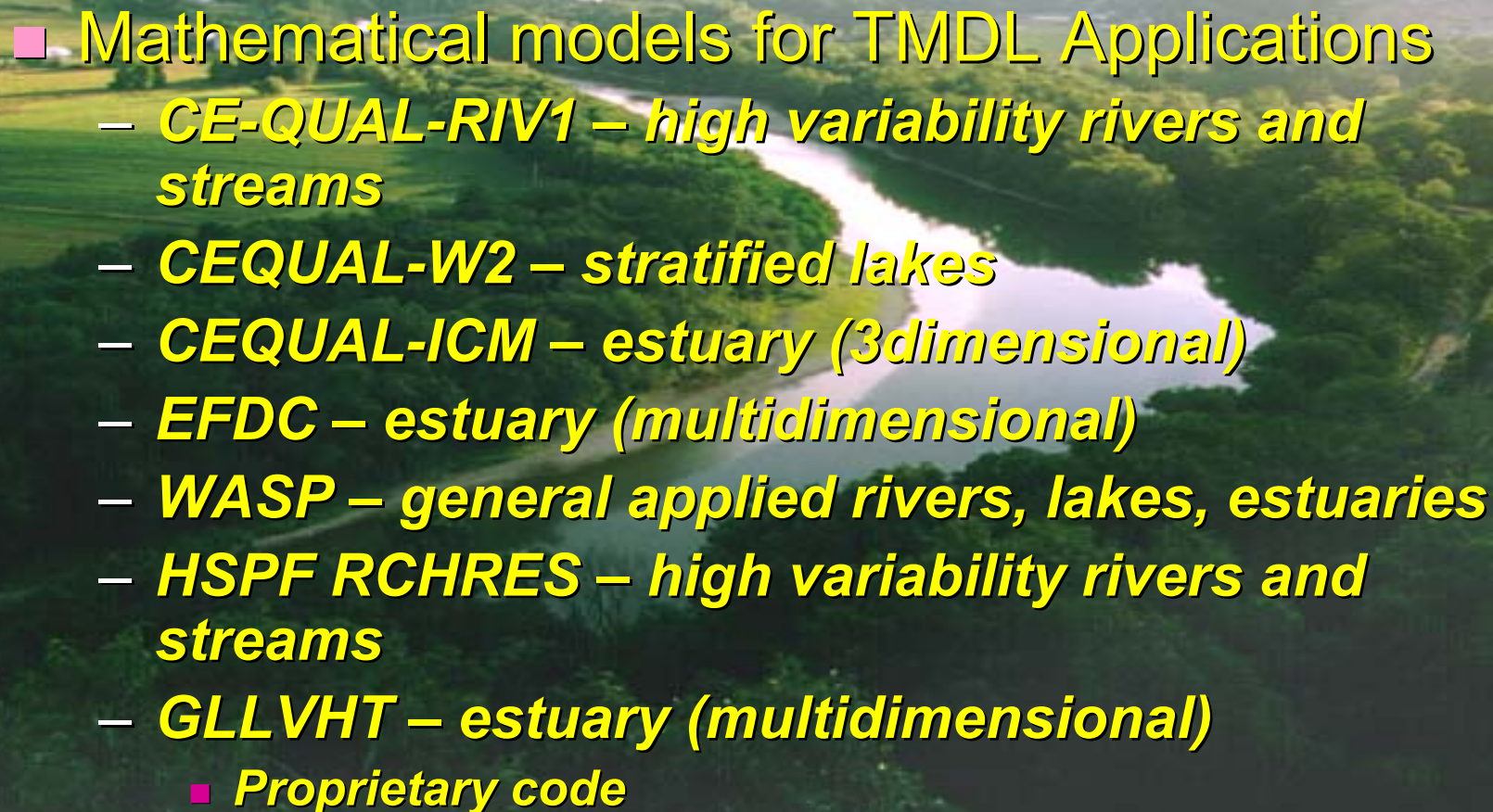   - Input and output conventions

Model Availability

- Existence of code
- Code obtainable
- Willingness developer to work on further development and enhancement

Step 3

- Recommend models for TMDL Applications
- *Total of 80 models identified*
  - *50 models eliminated in prescreening*
- *Remaining 30 models*
  - *23 removed from consideration*
    - *Inadequate representation of water quality variables and processes or because lacked dynamic hydraulics*
    - *Unavailability of code*
    - *Several reservoir/estuary models failed because of lack of multi-dimensionality*
    - *Linkage issues with HSPF*

Recommended Models

- Mathematical models for TMDL Applications
  - *CE-QUAL-RIV1 – high variability rivers and streams*
  - *CEQUAL-W2 – stratified lakes*
  - *CEQUAL-ICM – estuary (3dimensional)*
  - *EFDC – estuary (multidimensional)*
  - *WASP – general applied rivers, lakes, estuaries*
  - *HSPF RCHRES – high variability rivers and streams*
  - *GLLVHT – estuary (multidimensional)*
    - *Proprietary code*

Step 4

- **Ecological endpoints**
  - **Initially aquatic ecosystems**
    - **Ponds, lakes, reservoirs**
  - **Includes high trophic levels (primary, secondary and tertiary consumers)**
  - **Simulates impact of nutrients and sediment**